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METCUT RESEARCH ASSOCIATES INC CINCINNATI OHIO  
FOURTEENTH REPORT OF THE MACHINABILITY DATA CENTER.(U)  
JAN 81 J F KAHLES, J L KREBS

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DLA900-77-C-3197

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AMMRC TR-81-2

FOURTEENTH REPORT OF THE  
MACHINABILITY DATA CENTER.

11 JAN 1981

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10 JOHN F. KAHLES - JOHN L. KREBS  
Metcut Research Associates Inc.  
Cincinnati, Ohio

13 1 Jan 78 - 13 84.

FINAL REPORT - CONTRACT DLA 900-77-C-3197

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Prepared for

ARMY MATERIALS AND MECHANICS RESEARCH CENTER  
Watertown, Massachusetts 02172

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  <table border="0"> <tr> <td>Technical information center</td> <td>Operation</td> </tr> <tr> <td>Machining</td> <td>Reviews</td> </tr> <tr> <td>Information retrieval</td> <td>Data processing systems</td> </tr> <tr> <td>Costs</td> <td></td> </tr> </table>			Technical information center	Operation	Machining	Reviews	Information retrieval	Data processing systems	Costs	
Technical information center	Operation									
Machining	Reviews									
Information retrieval	Data processing systems									
Costs										
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <p>✓ This is the final report for the operation of the Machinability Data Center by Metcut Research Associates Inc. under government sponsorship. It is the culmination of a highly successful operation wherein all of the established goals have been achieved or exceeded. Cost savings through MDC's operation have been conservatively estimated to be over \$220 million from services provided since the Center began operation in 1964. (continued on reverse)</p>										

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Block No. 18

Supplementary Notes (cont.)

by modification P00005. The final report date was also amended to read 1430 DAC. Report AMMRC-TR 78-13 was previously submitted for performance under this contract covering the period 1 January 1977 to 31 December 1977 and is complementary to this report.

Block No. 20

Abstract (cont.)

During this reporting period, January 1, 1978 - September 30, 1980, the Center processed 424 specific inquiries, conducted 33 two-day seminars for 1,482 individuals, sold 7,370 copies of the Machining Data Handbook, and sold 5,710 copies of other MDC publications relating to modern material removal techniques.

-During this contract period, work was completed on the third edition of the Machining Data Handbook. This third edition is a greatly expanded and technically improved publication designed to meet the information demands of the manufacturing industry. The machining data are presented in both English and metric units to satisfy current U.S. needs. Handbook coverage is expanded from 1,100 to 1,500 materials and from 55 to 89 machining operations, including over 83,000 specific machining recommendations. New or expanded sections cover the nontraditional machining processes, machine chatter and vibration, surface finish and surface integrity, computer aided design and manufacturing, and grinding techniques. This new edition is expected to make a significant contribution toward reducing costs, increasing productivity, and increasing the service reliability of machined components. )

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## PREFACE

The Machinability Data Center has been operated by Metcut Research Associates Inc. continuously as a government sponsored Information Analysis Center since 1964. This is the final report of the operation of the Center by Metcut Research Associates Inc. under government sponsorship. The report is being submitted in accordance with the requirements of Contract DLA900-77-C-3197 issued by the Defense Electronics Supply Center, Dayton, Ohio 45444.

The original effective dates of this contract covered the period between January 1, 1977, and September 30, 1978, plus a one-year option to September 30, 1979. The option year was exercised by modification P00003 to the contract, and then the contract was extended one additional year to September 30, 1980, by modification P00005 to the basic contract.

One final report was submitted as required by the basic contract Data Requirements List, Exhibit A, Item A002, covering the period from January 1, 1977, through December 31, 1977. The requirement for a final report covering this particular time period was negated by modification P00003 to the basic contract dated October 1, 1978, which changed the report due date from 425 DAC to 1065 DAC. The final report due date was further changed to read 1435 DAC by modification P00005 to the basic contract dated October 1, 1979. Thus, this final report of the current contract complements the contents of the Thirteenth Annual Report of the Machinability Data Center, AMMRC TR 78-13, dated March 1978. The inclusive dates of this report are January 1, 1978, through September 30, 1980.

MDC, under government sponsorship, has been operated by Metcut Research Associates Inc., 3980 Rosslyn Drive, Cincinnati, Ohio 45209. Throughout the period of this contract, MDC has been administered by the Defense Logistics Agency, and since February 1980, more directly by the Defense Technical Information Center. Technical supervision has been provided by the Army Materials and Mechanics Research Center, Watertown, Massachusetts.

This report was released by Dr. John F. Kahles, Director of the Machinability Data Center in December 1980.

Acknowledgment is hereby made to the following individuals who have assisted MDC in the performance of its contractual obligations through the contract period:

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## INTRODUCTION

The Machinability Data Center has been operated by Metcut Research Associates Inc., 3980 Rosslyn Drive, Cincinnati, Ohio 45209, continuously as a government sponsored Information Analysis Center from 1964 until the termination of Contract DLA900-77-C-3197 on September 30, 1980. The Center operated as the Air Force Machinability Data Center under contract to the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, until 1972. From 1972 until final contract termination in September 1980, the Center was operated under contract to the Defense Logistics Agency.

During its tenure as a Department of Defense Information Analysis Center, MDC has made significant contributions toward advancing the state of the art in material removal through innovative and effective dissemination of machining data and machining technology. The Center has been fortunate in being at the forefront of machining technology. In this regard, MDC's position was fostered in part by the close association of the Metcut staff with other knowledgeable scientists and engineers in government, industry and the academic institutions of our own country and at the international level throughout the industrialized countries of the world. It was this unique position that provided justification for the creation and location of the Machinability Data Center at Metcut Research Associates Inc.

The overriding principle of operation at MDC has been to serve the needs of its inquirers and users and to generally help improve the state of the art of material removal operations. MDC's success can be measured by estimates of cost savings of over \$220 million as shown in table 9. Further evidence of MDC's contributions is the distribution of more than 83,000 publications relating to material removal operations through September 1980.

Probably the most important achievement of MDC has been the development, publication and distribution of the Machining Data Handbook. This handbook is recognized as the best-known available collection of starting recommendations for all machining operations. During the past two years of MDC's operation, this handbook has undergone a major revision resulting in the preparation of the 3rd edition for distribution beginning in November 1980. This new revision is a greatly expanded, two-volume work covering all of the material removal techniques for a wide variety and large number of currently used work materials. The handbook also presents information on subjects such as surface finish, surface integrity, computer aided design and computer aided manufacturing, nontraditional machining methods, and machine chatter and vibration. Data in the new handbook are presented in both English and metric units for universal appeal.

Another notable contribution of MDC has been the initiation of a seminar program entitled "Practical Machining Principles for Shop Application." This program was devised by MDC to fulfill a recognized need to upgrade the knowledge of engineers, supervisors and shop personnel in modern material removal techniques. The program has been an outstanding success, having been a sell-out from the inception of the program in 1974 through contract termination in September 1980.

## MDC SERVICES

### INQUIRY SERVICES

The summary of inquiry activity is shown in table 1 for this reporting period. These figures show no notable deviation from the recent past history of inquiry services.

### SEMINAR PROGRAM - "Practical Machining Principles for Shop Application"

The seminar program continued to be very popular and an important adjunct to the total information dissemination objectives of the Data Center. Almost every seminar was filled to capacity for each scheduled spring and fall series. Table 2 summarizes the history of MDC's seminar program since its inception in 1974. Table 12 is a listing of representative companies which have enrolled four or more employees in the seminar program and the number of employees from each company who have attended.

### DATA PUBLICATIONS

During this reporting period, MDC completed work on the Third Edition of the Machining Data Handbook and published two state-of-the-art reports. The first, MACHINING: A Process Checklist, was revised and reprinted. The second, LOW STRESS GRINDING: For Quality Production, was published in August 1978. Table 3 lists current MDC publications.

The extensively revised third edition of the Machining Data Handbook represents a major contribution to machining in government and in industry. Use of the handbook will have a significant impact on reducing machining costs, increasing productivity and improving the reliability of components manufactured for DoD.

Completely revised and expanded, the third edition contains 2,304 pages as compared to 1,040 pages in the previous edition. The number of workpiece materials has been increased from 38 material groups (over 1,100 materials) to 61 material groups (over 1,500 materials). Coverage has also been increased from 55 operations to 89 operations, thereby bringing the total number of machining recommendations to over 83,000.

Recent advances in machining technology have been included in the third edition of the Machining Data Handbook. Major new features contained in the new edition include:

1. Machining data in both English and metric units.
2. Tool material recommendations in both U.S. and ISO standard grades.
3. Recommendations for machining using the new coated-carbide inserts.
4. Data for more depths of cut for turning, milling and other operations.

5. Greatly expanded information and data for 30 nontraditional machining processes.
6. Completely revised section on machine chatter and vibration to ease troubleshooting or problems.
7. Tables for estimating surface finish.
8. Introduction to computer aided manufacturing including group technology, adaptive control and computerized process planning.
9. Guidelines for grinding.

In addition, revised and expanded coverage has been given in the new edition to topics such as surface integrity, cutting fluids, and NC machining. The materials index has been revised and restructured to include the Unified Numbering System for alloys where possible. Chemical compositions of alloys are listed by material group. The composition of an alloy that is new or not listed in the new handbook can be compared to those listed to determine which material group is comparable in order to estimate the approximate machinability of the new alloy.

The state-of-the-art report Low Stress Grinding (MDC 78-103) describes the special combinations of grinding parameters which produce high integrity surfaces and discusses these parameters in relation to their impact on productivity. While labeled "low stress grinding," the designation actually encompasses all of the considerations for producing high integrity surfaces, with low surface residual stress being but one of the elements. Practical combinations to achieve both productivity and high integrity are covered. Quality assurance checks and surface integrity results are detailed, and checklists for rapid fault diagnosis are included. This publication is intended principally for manufacturing, design or quality assurance engineers who wish to -

1. Avoid grinding cracks and burns.
2. Utilize high integrity abrasively ground components.
3. Grind high strength steels, superalloys or other sensitive alloys.
4. Reduce grinding manufacturing losses.
5. Reduce stresses in critical or highly loaded components.
6. Enhance the surface integrity obtainable by grinding.
7. Attain adequate producibility while assuring the quality of the ground surface being produced.

Publication sales have been satisfactory during the reporting period as given in table 4.

#### COMPUTER PROGRAMS

The NCECO (NC ECONOMICS) computer program was first developed by Metcut and was then made available to MDC for sale to industry in 1973. A modified version of this program in the form of programmable calculator strips for use with hand-held calculators has been completed, and the strips are now sold by MDC for use by shop and engineering personnel who may not have ready access to a computer.

Both NCECO and the calculator strips are applicable to NC and conventional machine tools. These programs facilitate the investigation and economic analysis of the many alternative machining conditions available for production use. Using these programs, economic machining conditions can be determined before a part is put into production; consequently, a machine tool producing a part can be operated to give the lowest part cost, or the maximum production rate, or some combination of both, depending upon production demands.

The computer program and calculator strips can also be used for estimating costs, preparing quotations and determining areas where cost-effective improvements should be directed in view of new developments, such as increased labor and overhead rates, new tool materials and alternative work materials. Sales of computer programs and calculator strips are shown in table 5.

#### INCOME FROM MDC SERVICES

Table 6 summarizes the income distribution from MDC's information transfer activities during the period of this report. This table itemizes the income from each type of activity, namely, handbooks and other publications, computer programs and calculator strips, inquiries, and the seminar program. A statistical summary of the Data Center's total activity during this reporting period is given in table 11.

#### SOURCES OF MACHINING INFORMATION

Table 7 summarizes MDC's activities relating to document acquisition in this reporting period. This table indicates that 1,310 documents were screened but contained no useful information for addition to MDC's document holdings. The apparent disparity between the number of documents judged significant and the total number of documents accessed arises from the fact that a single-screened source document often produces more than one independent secondary document for inclusion in the document file.

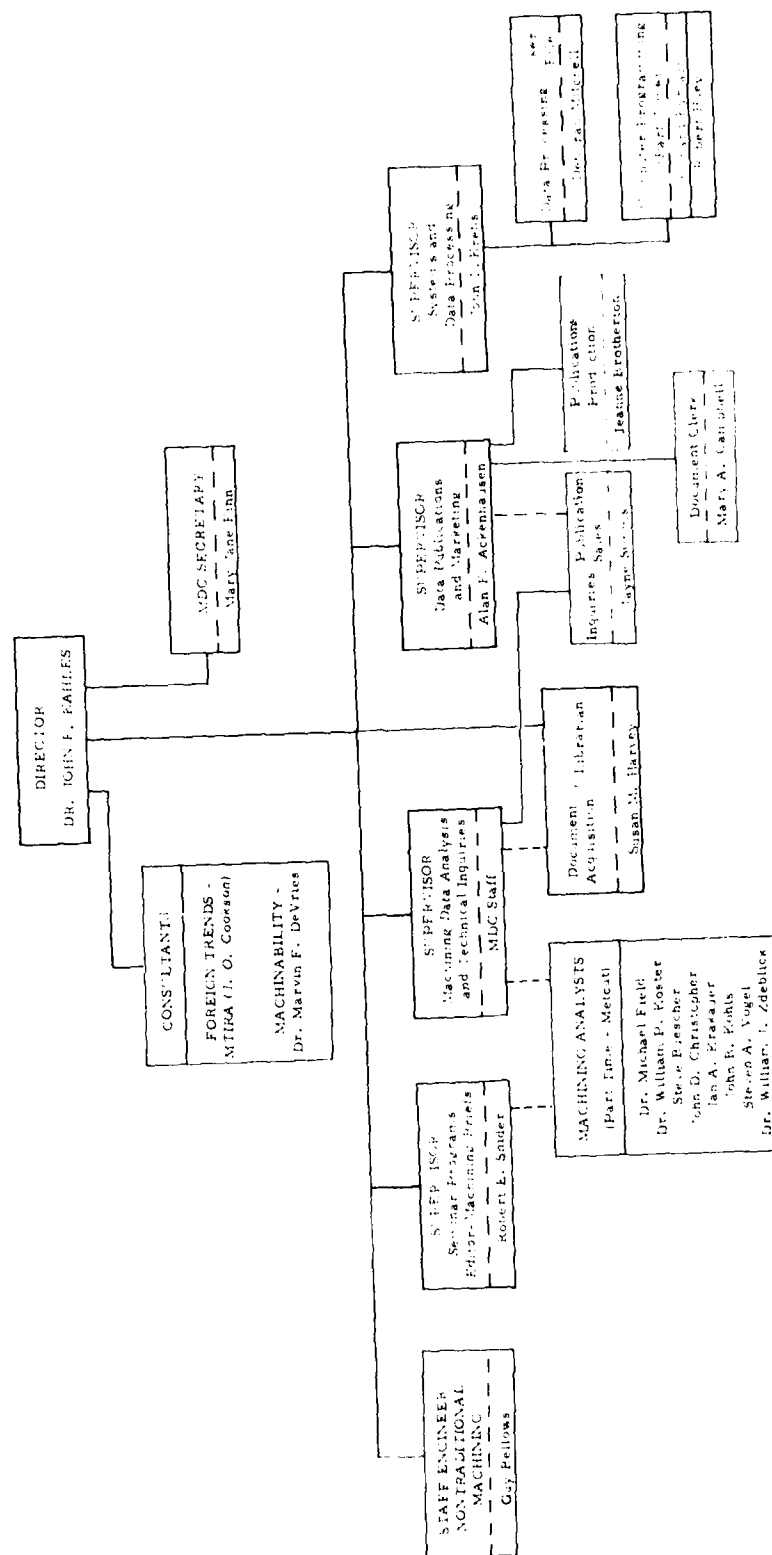
The status of the hard-copy document file is displayed in table 8. The total number of documents by file type as well as by source category are depicted. A breakdown of the source file is also shown by the number of sources for each of the major source categories.

## ECONOMIC ANALYSIS OF MDC'S OPERATIONS

Table 9 is an analysis of the cumulative effect of the availability of the products and services of the Machinability Data Center towards cost savings to its users. The numbers used in the computations include the total number of inquiries answered by the Data Center since its beginning and the total number of data publications sold and/or placed in distribution by the Data Center. The other input is the dollar savings per machining situation and the average number of machining situations serviced by each inquiry and/or individual data publication. These figures are then totaled to produce a dollar value which is the estimated total savings resulting from the operation of the Machinability Data Center.

Table 10 is an economic analysis of the metal cutting industry in the United States. These figures include the total number of metal cutting machine tools in use today and the average labor input plus the cost of labor and overhead for an average number of hours per individual working year. The estimates of the number of machine tools are extracted from the American Machinist Twelfth Inventory (1976 - 1978). The other basic information is provided by the U.S. Department of Commerce sources.

FIGURE 1  
MACHINABILITY DATA CENTER  
ORGANIZATION CHART



Operated by Metall Research Associates Inc.  
under Contract DNA 44-011

TABLE 1 - INQUIRY ACTIVITY  
(January 1, 1978 - September 30, 1980)

Paid technical inquiries . . . . .	91
No-charge (telephone) inquiries . . . . .	333
Total inquiries processed . . . . .	424
Income from 91 paid technical inquiries . . . . .	\$ 12,993.
Average income per paid inquiry . . . . .	\$ 143.
Cost of inquiry services . . . . .	\$ 56,385.
% Cost recovery for inquiry processing . . . . .	23
Total cost recovery income from all sources . . . . .	\$773,435.
% Income from inquiry services . . . . .	1.7
Man-hours expended in inquiry processing . . . . .	1,325
Total man-hours for Center operation . . . . .	33,647
% Man-hours for inquiry services . . . . .	3.9

<u>INQUIRIES BY TYPE</u>	<u>Paid</u>	<u>No Charge</u>
High temperature alloys	6	24
Cutting fluids	2	10
Cutting tools	3	17
Surface integrity	2	23
Nontraditional machining processes	8	69
Cost	1	2
CAD/CAM	3	3
General machining	63	182
Bibliography	3	3
Total	91	333

<u>INQUIRIES BY SOURCE</u>	<u>Paid</u>	<u>No Charge</u>
Government		
DoD	3	16
Non-DoD	3	17
Educational institutions	5	11
Private industry	80	289
Total	91	333

TABLE 2 - SEMINAR PROGRAMS

	<u>During this Contract Period</u>	<u>1974 - 1980*</u>
Two-day seminars held	33	84
Attendees	1,482	3,181
Organizations represented	---	1,187
States represented	---	43

-----  
 \*Totals are cumulative from Spring 1974 through Spring 1980.

TABLE 3 - LIST OF CURRENT MDC PUBLICATIONS  
(in order by publication dates)

MACHINING DATA HANDBOOK, Third Edition, 2,304 pages, 8-1/2 x 11 in., hardbound, 1980.

LOW STRESS GRINDING: For Quality Production, MDC 78-103, 112 pages, 5-1/2 x 8-1/2 in., paperbound, August 1978.

MACHINING: A Process Checklist, MDC 78-100, 20 pages, 5-1/2 x 8-1/2 in., paperbound, May 1976, Revised June 1978.

CHEMICAL MACHINING: Production with Chemistry, MDC 77-102, 76 pages, 5-1/2 x 8-1/2 in., paperbound, February 1977.

GROUP TECHNOLOGY: An Overview and Bibliography, MDC 76-601, 90 pages, 5-1/2 x 8-1/2 in., paperbound, August 1976.

NONTRADITIONAL MACHINING GUIDE: 26 Newcomers for Production, MDC 76-101, 74 pages, 5-1/2 x 8-1/2 in., paperbound, August 1976.

MACHINING OF HIGH STRENGTH STEELS WITH EMPHASIS ON SURFACE INTEGRITY, AFMDC 70-1, 268 pages, 8-1/2 x 11 in., hardbound, 1970.

DETERMINATION AND ANALYSIS OF MACHINING COSTS AND PRODUCTION RATES USING COMPUTER TECHNIQUES, AFMDC 68-1, 124 pages, 8-1/2 x 11 in., paperbound, August 1968.

GRINDING RATIOS FOR AEROSPACE ALLOYS, AFMDC 66-2, 20 pages, 8-1/2 x 11 in., paperbound, June 1966.

MACHINING DATA FOR BERYLLIUM METAL, AFMDC 66-3, 26 pages, 8-1/2 x 11 in., paperbound, June 1966.

TABLE 4 - QUANTITY OF MACHINING DATA PUBLICATIONS SOLD  
(January 1, 1978 - September 30, 1980)

Handbooks		
Machining Data Handbook, 2nd Edition	5,294	
Machining Data Handbook, 3rd Edition	<u>2,076</u>	7,370
State-of-the-Art Reports		
Machining: A Process Checklist	1,387	
Nontraditional Machining Guide	1,040	
Group Technology	1,189	
Chemical Machining	690	
Low Stress Grinding	<u>999</u>	5,305
Other Data Publications (prior contracts)		<u>405</u>
		13,080

TABLE 5 - SALES OF COMPUTER PROGRAMS AND  
PROGRAMMABLE CALCULATOR STRIPS  
(January 1, 1978 - September 30, 1980)

NCECO (NC EConomics) computer program . . . . .	18
Calculator strips . . . . .	92

TABLE 6 - INCOME DISTRIBUTION FROM MDC INFORMATION  
TRANSFER ACTIVITIES  
(January 1, 1978 - September 30, 1980)

Inquiries . . . . .	\$ 12,993
Seminars . . . . .	427,149
Machining Data Handbook . . . . .	287,966
Other data publications . . . . .	37,952
Computer program and calculator strips . . . . .	<u>7,375</u>
Total . . . . .	\$773,435

TABLE 7 - DOCUMENT ACQUISITION  
(January 1, 1978 - September 30, 1980)

DOCUMENTS SCREENED*	
Significant . . . . .	2,190
Nonsignificant . . . . .	<u>1,318</u>
Total . . . . .	3,508
DOCUMENTS ACCESSED†	
Primary . . . . .	811
Secondary . . . . .	<u>2,013</u>
Total . . . . .	2,824
DOCUMENTS ENTERED INTO SYSTEM§ . . . . .	1,476

\*Documents screened - refers to all types of publications, including periodicals, trade journals, conference proceedings, etc.

†Documents accessed - refers to those which have been selected for entry into MDC's document file. Secondary documents include such references as an article extracted from a periodical or an individual technical paper selected from a published volume of conference proceedings, etc. Primary documents include source data, such as contractor reports, which are entered into the system as received. Documents in this category are counted in the inventory of MDC's total data base.

§Documents entered into the system include primary and secondary documents which have been coded and referenced on the computer search files.

TABLE 8 - STATUS OF MDC DOCUMENT FILES  
(September 30, 1980)

DOCUMENT FILE TOTALS\*

Regular file . . . . .	30,232
Surface integrity file . . . . .	3,476
Inquiry file . . . . .	<u>8,132</u>
Total† . . . . .	41,840

BREAKDOWN OF SOURCE FILE

DoD sources§ . . . . .	59
Educational institutions . . . . .	96
Government, Non-DoD . . . . .	17
Nongovernment open literature	
Domestic . . . . .	904
Foreign . . . . .	<u>476</u>
Total . . . . .	1,552

DOCUMENT TOTALS BY SOURCE

DoD . . . . .	1,971
Other Government . . . . .	493
Nongovernment	
Domestic . . . . .	30,356
Foreign . . . . .	<u>9,020</u>
Total . . . . .	41,840

\*Regular file - refers to the main document file which supports MDC's activities. Surface integrity file - refers to a segment of the main file pertaining to the special subject of surface integrity. Inquiry file - contains inquiries are coded and filed in a similar manner to other documents and are used to assist in answering specific technical inquiries.

†The document total is not an absolute number. It includes the cumulative total of documents added to the system. It does not consider documents deleted from the system since document purging is a day-to-day event through continued evaluation as documents are retrieved and referenced.

§DoD sources - includes DoD installations plus companies and educational institutions which generate source documents under government contract and other source documents which result from their own research.

TABLE 9 - CALCULATION OF ESTIMATED COST SAVINGS RESULTING FROM MDC'S OPERATION  
(October 1964 - September 1980)

	Number Sold	Machining Situations Utilized per Item*	Total Machining Situations Utilized*	Savings per Machining Situation*	Estimated Cost Savings
INQUIRIES . . . . .	8,132	5	40,660	\$800	\$ 32,528,000
MACHINING DATA HANDBOOKS					
ORDP 40-1\$ . . . . .	4,500				
1st edition# . . . . .	15,000				
2nd edition . . . . .	26,878				
	46,378	10**	463,780	\$300	139,134,000
OTHER PUBLICATIONS†† . . . . .	32,890	5**	164,450	\$300	49,335,000
				Total . . . . .	\$220,997,000

\*Estimated.

\*\*Machining situations utilized per item refers to each inquiry answered or each publication sold.

§Forerunner of Machining Data Handbook. These copies were sold by U.S. Government.

#Includes 9,000 hardbound + 6,000 softbound copies. The 6,000 softbound copies were sold by the U.S. Government.

\*\*These estimates are very conservative. They reflect only 10 and 5 usages respectively for the life of each publication sold.

††Excluding Machining Data Handbook.

TABLE 10 - MACHINING COSTS IN THE U.S.A.

APPROXIMATE ANNUAL LABOR AND OVERHEAD COSTS FOR OPERATING METAL CUTTING MACHINE TOOLS IN INDUSTRIES IN THE UNITED STATES

Total number of metal cutting machine tools	= 2,301,500*
Average labor cost + overhead	= \$25 per hour
Average working day	= 8 hours
Number of working days per year	= 250
Average number of direct labor personnel per machine	= 1
Total cost of labor + overhead:	
2,301,500 x \$25 x 8 x 250 x 1	= \$115,075,000,000

It appears reasonable to conclude that the cost of labor + overhead for machining required for manufacturing in the U.S.A. is of the order of:

\$115,000,000,000 Annually

\*Based on 12th American Machinist Inventory (1976 - 1978). (See summary in American Machinist, December 1978, pp. 133-148.)

METAL CUTTING TYPE METALWORKING MACHINERY INCLUDING EXPORTS (SIC 3541)  
Total Value of Shipments (millions of dollars):

<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
1,790	2,206	2,750	3,350

MACHINE TOOL ACCESSORIES AND MEASURING DEVICES (SIC 3545)  
Total Value of Shipments (millions of dollars):

<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
2,372	2,725	3,175	3,600

The above totals for machine tool accessories and measuring devices include the following shipments for cutting tools (millions of dollars):

	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
Total	1,344	1,650	1,925	2,200
Carbide	580	720	840	970
High Speed Steel	764	930	1,085	1,230

All values other than 1977 are estimated.

Data supplied by the U.S. Department of Commerce, Bureau of Industrial Economics.

TABLE 11 - STATISTICAL SUMMARY FOR JANUARY 1, 1977 - SEPTEMBER 30, 1980

INFORMATION ANALYSIS CENTER CONTRACT STATUS REPORT				NAME OF INFORMATION ANALYSIS CENTER Machinability Data Center				QUARTER ENDING	CUMULATIVE THRU 1/1/77-9/30/80
AREA TITLE	OUTPUT UNITS PRODUCED	MANHOURS EXPENDED			COSTS INCURRED			INCOME	
		PRO- FESSIONAL	NON PRO- FESSIONAL	TOTAL	DIRECT	INDIRECT	TOTAL		
1. ACQUISITION AND INPUT OF SOURCE INFORMATION		4,379	2,763	7,142	95,340	135,922	231,262		
2. DOCUMENTS ACQUIRED									
3. DOCUMENTS REVIEWED									
4. DOCUMENTS CATALOGED									
5. TECHNICAL INQUIRY RESPONSES PROVIDED		1,700	170	1,870	28,752	44,039	72,791	19,566	
6. BIBLIOGRAPHIC INQUIRY RESPONSES PROVIDED									
7. HANDBOOKS/DATA BOOKS COMPLETED		13,899	4,129	18,028	625,317	410,460	1,035,777	344,730	
8. NEW CHAPTERS/PAGES COMPLETED									
9. REVISED CHAPTERS/PAGES COMPLETED									
10. DATA SETS COMPILED									
11. STATE-OF-THE-ART STUDIES COMPLETED		1,329	264	1,593	22,562	33,038	55,600	60,170	
12. CRITICAL REVIEWS AND/OR TECHNOLOGY ASSESSMENTS COMPLETED									
13. CURRENT AWARENESS AND PROMOTION EFFORTS		3,909	198	4,107	236,028	83,545	319,573		
14. NUMBER NEWSLETTERS AND/OR ANNOUNCEMENTS PUBLISHED									
15. NUMBER MEETINGS CONFERENCES ETC SUPPORTED									
16. SEMINARS		5,185	578	5,763	146,666	124,042	270,708	529,174	
17. MANAGEMENT AND SUPPORT		3,619	3,324	6,943	68,679	132,270	200,949		
18. UNASSIGNABLE INDIRECT COSTS									
19. TOTAL		34,020	11,426	45,446	1,223,344	963,316	2,186,660	953,640	

TABLE 12 - ORGANIZATIONS WITH 4 OR MORE ATTENDEES

Represented at MDC's Seminars on  
 "Practical Machining Principles for Shop Application"  
 (Spring 1974 through Spring 1980 - 84 seminars)

<u>Company</u>	<u>No. of Attendees</u>	<u>Company</u>	<u>No. of Attendees</u>
ARO, Inc.	21	Clark Equipment Co.	5
A-T-O Inc.	14	Clow Corp.	4
Abex Corp.	9	Colt Industries	7
Aeroquip Corp.	9	Contraves-Goerz Corp.	8
AIResearch Mfg. Co.	5	Cooper Energy Services	5
Akron Standard	6	Copperweld Spec. Steel Co.	5
Allen-Bradley	7	Cross Corp.	25
Allis-Chalmers Corp.	54	Cummins Engine Co.	28
Aluminum Co. of America	7	Cutler-Hammer, Inc.	7
American Custom Metals	5		
American LaFrance	4	Dana Corp.	89
Anderson IBEC	6	Dayton Walther	8
Andrew Corp.	4	Dearborn, Howard, Inc.	13
Armstrong Machine Works	6	Deere & Co.	16
Atlas Crankshaft	12	Deere, John	22
		Defense Contract Admin. Serv.	
Babcock & Wilcox	65	Management Area	8
Barnes, W.F. & John, Co.	8	Delaval Turbine Inc.	7
Battelle	6	DeVlieg Machine Co.	4
Bell Helicopter Co.	8	DeZurik	8
Bell Telephone Laboratories	10	Diamond Chain Co.	5
Beloit Corp.	4	Dover Corp.	7
Bendix Corp.	19	Dresser Industries	10
Black Clawson Co.	4	Duff-Norton	10
Boeing Co.	11	Dupps Co.	4
Brush Wellman	4	Duriron	4
Budd Co. (The)	8		
		Eaton Corp.	46
C.E. Cast Equipment	4	Electric Machinery Mfg. Co.	8
CMI Corp.	6	Electric Wheel Co.	4
Carlyle Compressor Co.	7	Elliott Corp.	10
Carmet Co.	5	Emerson Electric	9
Carpenter Technology Corp.	5	Enerpac	4
Case, J.I., Co.	4	Ex-Cell-O Corp.	7
Caterpillar Tractor	5		
Chamberlain Mfg. Corp.	14	FMC Corp.	6
Chemetron Corp.	8	Falk Corp.	17
Chrysler Corp.	11	Federal Mogul Corp.	6
Cincinnati Inc.	5	Fisher Controls Co.	17
Cincinnati Milacron Inc.	25	French Oil Mill Mach. Co.	11
Cincinnati Tool	4		

TABLE 12 (cont.)

<u>Company</u>	<u>No. of Attendees</u>	<u>Company</u>	<u>No. of Attendees</u>
General Dynamics	33	NIBCO, Inc.	14
General Electric Co.	53	Namco Controls	4
General Motors Corp.	63	National Supply	4
Gilbarco Inc.	4	Naval Avionics Facility	17
Gleason Works	7	Niagara Machine	8
Goodyear Aerospace Corp.	16	Nooter Corp.	4
Gould Inc.	8		
Gray, G. A., Co.	15	Ohio Brass Co.	5
Grumman Aerospace Corp.	26	Ohio Nuclear Co.	5
		Olin Corp.	14
Hamilton Standard	7	Otis Engineering	6
Harris Corp.	4		
Hewlett-Packard	14	Package Machinery	5
Hitachi, Ltd. (Japan)	7	Parker-Hannifin Corp.	13
Hobart Corp.	16	Philadelphia Gear	4
Honeywell, Inc.	4	Pitney Bowes	4
Hydril Co.	4	Portsmouth Naval Shipyard	4
		Powell, William	5
IBM Corp.	19	Procter & Gamble	6
Ingersoll-Rand Co.	18	Pratt & Whitney	10
International Harvester Co.	23		
International Nickel Co.	4	Reece Corp.	4
		Reliance Electric	5
JAMCO International	4	Remington Arms Co.	8
Jeffrey Mfg. Co.	5	Remmele Engrg. Inc.	5
Jordan Valve	6	Republic Steel Corp.	4
Joy Manufacturing Co.	12	Reuland Electric Co.	4
		Rexnord Inc.	14
Kingsbury Machine Tool Co.	4	Reynolds Metals Co.	4
Koehring Co.	6	Reynolds, R. J., Tobacco Co.	5
Kollmorgen Corp.	6	Robbins & Myers	4
Koppers-Sprout-Waldron	16	Rockwell International	88
Kunkle Valve Co.	4		
		SKIL Corp.	6
LaBour Pump Co.	5	Sandia Labs.	4
Lawrence Livermore Labs.	14	Schwitzer Engineered Comp.	37
Lockheed	11	Sealed Power Corp.	7
		Senco Products, Inc.	7
MCC Marpac	11	Setco Industries	5
Martin Marietta Corp.	8	Signode Corp.	7
Master Chemical Corp.	4	Simmonds Precision	4
McCorkle Machine Shop	4	Smith, A. O.	5
McDonnell Douglas Corp.	16	Snyder Corp.	5
Mechanical Mfg. Inc.	4	Sperry Vickers	7
Megadiamond Industries	9	Stanadyne	5
Minster Machine	8	Strippit-Houdaille	5
Moog, Inc.	9	Sundstrand Corp.	5
Muskegon Piston Ring Co.	6	Super-Cut, Inc.	6

TABLE 12 (cont.)

<u>Company</u>	<u>No. of Attendees</u>
TRW	28
Teledyne	13
3M Co.	6
Thrush Products, Inc.	4
Timex	4
Tomkins-Johnson Co.	4
Tool Crib, Inc. (The)	4
Torrington Co.	4
Tyson Bearing Co.	4
U.S. Army Tank Automotive Command	4
USAF, Wright-Patterson AFB	5
Union Carbide Corp.	39
Union Pump Co.	9
United Nuclear	6
Upson Machine Products Inc.	6
Valeron Corp.	13
Viking Pump Co.	8
Warner Electric Brake & Clutch Co.	5
Warner & Swasey	12
Washington Mould, Machine & Foundry Co.	5
Waupaca Foundry	6
Weatherhead Co.	7
Western Gear Corp.	6
Westhoff Tool & Die Co.	5
Westinghouse Electric Corp.	27
Wyman-Gordon Co.	7
Xtek, Inc.	31
Total 4 or more:	188
10 or more:	51
20 or more:	20
30 or more:	11

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DATA CENTER - John F. Kahles, John L. Krebs  
Metcut Research Associates Inc.  
Cincinnati, Ohio 45209  
KEY WORDS  
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Machining - Information Retrieval  
Costs - Operation  
Reviews - Data Processing Systems

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32 pp. - 11 illus, tables, Contract DAAH01-77-C-3197

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